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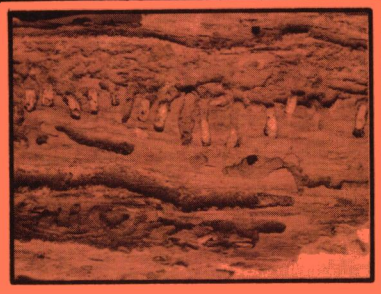

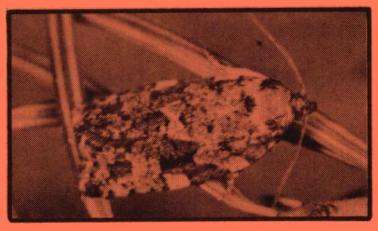

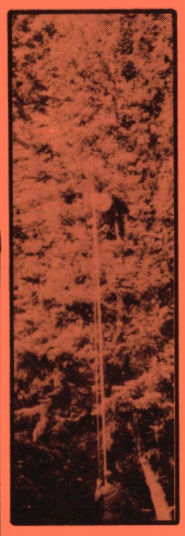

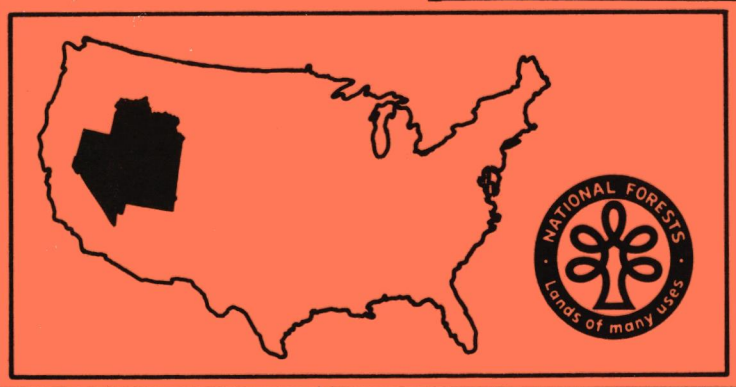

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# IMPACT OF DEFOLIATION BY WESTERN SPRUCE BUDWORM BOISE AND PAYETTE NATIONAL FORESTS AND INTERMINGLED FEDERAL, STATE, AND PRIVATE LANDS 1977

Max Ollieu, Ladd Livingston, and Wayne Bousfield

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# IMPACT OF DEFOLIATION BY WESTERN SPRUCE BUDWORM BOISE AND PAYETTE NATIONAL FORESTS AND INTERMINGLED FEDERAL, STATE, AND PRIVATE LANDS

1977

by

Max Ollieu [1/], Ladd Livingston [2/], and Wayne Bousfield [3/]

## INTRODUCTION

Defoliation by western spruce budworm, Choristoneura occidentalis, Freeman, occurred again on the Boise and Payette National Forests and intermingled lands in 1977 (Knopf 1977a, 1977b). Infested acreages totaled 777,202, which included 239,000 acres within the Primitive Area.

An expanded western spruce budworm impact evaluation was conducted in 1977 to provide data for an Environmental Impact Statement. Personnel from the Intermountain Region, USDA Forest Service, and the Idaho Department of Lands conducted the field phase. Forest Insect and Disease Management, USDA Forest Service, Missoula, provided assistance in survey design, data management, and analysis.

## METHODS

Stands chosen for the impact evaluation were located either within or in close proximity to the 1977 area of defoliation shown in Figure 1. Type maps and color resource photographs were used to help identify grand fir and Douglas-fir stands. Approximately 60 stands were selected on a modified grid basis to distribute sample sites over the infestation area.

Three two-person crews collected field data from mid-July to mid-August according to the survey technique designed by FIDM, Region 1 (Bousfield and Williams 1977) and used for the impact survey for the Boise-Payette infestation in 1976 (Ollieu, Livingston and Bousfield 1977). Plot centers were established on a 5 x 10 chain grid within the stands, with a minimum of 10 and a maximum of 20 plots per stand. Each center was used to establish a variable and fixed plot. Variable plots provided information

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on tree species, dbh, height, and damage from defoliation by western spruce budworm to tree ≥ 5 inches dbh. Fixed plots provided information on trees < 5 inches dbh by species and damage from defoliation by western spruce budworm. Defoliation by western spruce budworm was assigned values as shown below:

0 = no defoliation
1 = current year defoliation
2 = current plus older defoliation
3 = 10% or less top-kill
4 = 11% to 33% top-kill
5 = more than 33% top-kill
6 = tree mortality attributed to western spruce budworm

Increment cores were taken from three species within each stand to determine periodic annual increment and reduction in radial growth due to defoliation by western spruce budworm. Approximately 20 cores were taken from each of the three species whenever possible. Generally, grand fir (most susceptible), Douglas-fir (less susceptible), and ponderosa pine (non-host) were chosen for sampling. Covariance analysis was employed to adjust radial growth means and allow comparisons to be made.

This impact evaluation was designed to provide information to forest resource managers in central Idaho on effects of western spruce budworm. An Environmental Impact Statement, which addresses stands affected by western spruce budworm and considers management alternatives, draws upon this evaluation. Therefore stands have been grouped into Analysis Units as developed for the EIS. Analysis Units are composites of numerical values which depict defoliation intensity over time. Five Analysis Units have been arbitrarily chosen to rank defoliation over time from none to severe. During the annual sketch-mapping survey of the Intermountain Region, defoliation is rated light, moderate, or heavy. By assigning a value of 1 = light, 2 = moderate, and 3 = heavy, affected areas of forest can be numerically rated for defoliation intensity. Cumulation of intensity ratings over time can help to display how areas have been affected during the infestation. For instance, a stand heavily defoliated (3) for nine years (9) would have a value of (3 x 9) = 27 and fall into the severe category. The five Analysis Units are shown below with numerical rating range and defoliation intensity:

| Analysis Unit | Numerical Rating | Defoliation Intensity |
|---|---|---|
| 1 | 0 | none |
| 2 | 1-6 | light |
| 3 | 7-12 | moderate |
| 4 | 12-22 | heavy |
| 5 | ≥ 23 | severe |

## RESULTS

### Variable Plots

Analysis Units 3, 4 and 5 which represent stands in areas which experienced moderate, heavy and severe defoliation over the period of infestation are presented in Table 1. Twenty-six stands were included in this grouping. Stands averaged 145 trees per acre and 27,363 board feet per acre. Defoliation by western spruce budworm caused some degree of top-killing to a total of 22.7 percent of the trees (33 T/A). Mortality attributed to western spruce budworm was 0.5 percent of the stems (0.9 T/A) on the variable plots. Volume of mortality was calculated to be 122 board feet per acre.

Grand fir on the variable plots made up 48 percent of the trees and 49 percent of the volume. Approximately 18 percent of all plot trees were top-killed grand fir. Considering top-kill of tree species individually, 37 percent of all grand fir were top-killed, 36 percent of all subalpine, 12 percent of all Engelmann spruce and 9 percent of all Douglas-fir were top-killed. Mortality attributed to defoliation by western spruce budworm totals 1 percent for grand fir and 2 percent for Engelmann spruce. Again, these data are averages for stands moderately to severely affected during this most recent infestation period and consider only trees 5 inches dbh and larger.

### Fixed Plots

Combination of data from Analysis Units 3, 4 and 5 for fixed plots shows 788 trees per acre < 5 inches dbh (Table 2). Grand fir comprised 41 percent of the stems (323.5 T/A), Douglas-fir 21.5 percent (170 T/A), and Engelmann spruce 14 percent (110.8 T/A). Top-killing was recorded in 19.8 percent of the stems (157 T/A) and mortality in 3.7 percent (29.3 T/A). Considering impact of defoliation on individual tree species for trees < 5 inches dbh, subalpine fir displayed 34 percent top-kill and 21 percent mortality, grand fir showed 30 percent top-kill and 2 percent mortality, Engelmann spruce 12 percent top-kill and 5 percent mortality and Douglas-fir 10 percent top-kill with no mortality.

### Growth Loss

Growth loss was computed by stand, tree species, and size class using increment core and top-kill data. Table 3 shows growth loss for grand fir and all species by Analysis Unit and stand. Stands in Analysis Unit 3 showed grand fir to be growing 87 percent of normal with 38 BF/A growth loss per year. Analysis Unit 4 showed grand fir growing 88 percent of normal with 30 BF/A per year growth loss. Only two stands were sampled in Analysis Unit 5 and growth loss data were only available from one of the two. Therefore, the sample cannot be considered representative for the area. Within the three Analysis Units the lowest percent of normal growth for grand fir was 63 percent and the greatest growth loss of grand fir volume was 91 BF/A per year.

## Discussion

The impact survey sampled 44 stands in 1977 over the commercial forest affected by western spruce budworm. Analysis Units 3, 4, and 5 represented stands moderately, heavily, and severely defoliated for the infestation period. Twenty-six stands were included in Analysis Units 3, 4, and 5.

Top-kill as recorded from the 14 stands sampled in 1976 was greater (34 percent) than that recorded from the 26 stands sampled in 1977 (23 percent). The 1977 results should better represent the infestation area as more stands were sampled over a larger area. Mortality was not observed in 1976 on trees ≥ 5 inches dbh; however, 0.5 percent (122 BF/A per year) was recorded in 1977. Grand fir in Analysis Units 3, 4, and 5 showed growth to be 87 percent of normal and growth loss to be 36 BF/A per year.

Top-kill of trees < 5 inches dbh was 20 percent overall with subalpine fir registering 34 percent, grand fir 30 percent, Engelmann spruce 12 percent and Douglas-fir 10 percent. Mortality was 3.7 percent overall with subalpine fir showing 20 percent, Engelmann spruce 5 percent and grand fir 2 percent. These figures are considerably higher than the 8 percent top-kill and 0.1 percent mortality of trees < 5 inches dbh recorded in 1976. The average number of trees per acre on fixed plots was very close for the two surveys: 791 T/A in 1976 and 788 T/A in 1977.

In 1977 a much better picture of impact from defoliation by western spruce budworm was obtained for the Boise-Payette infestation. Top-killing and mortality by tree species and size class were documented. No data were recorded on impact of defoliation by western spruce budworm on cone production or rootlet growth. Williams 1963 reported radial growth at dbh for grand fir showed the least growth decline of any portion of the bole. Therefore additional studies to determine the effect of defoliation on radial growth along the bole are needed. Williams 1963 also showed internodal growth of grand fir to be only 17 percent of normal in heavily defoliated trees, Engelmann spruce 36 percent of normal and Douglas-fir 64 percent of normal. Height growth slowdown was not considered in the present analyses unless top-killing was recorded. Consequently both radial and height growth loss are only conservatively estimated. Effect of top-killing on growth loss was considered; however, refinements are needed to determine effect of top-killing on quantity and quality of wood.

## Recommendations

1. Federal, State and private forest resource managers should complete the Environmental Impact Statement on western spruce budworm for the Boise-Payette infestation.

2. Forest resource managers with stands defoliated by western spruce budworm should consider alternative management actions where impacts of budworm defoliation and resource values warrant.

3. Alternative silvicultural techniques which may lessen impact of defoliation by budworm include: (1) removal of true fir overstory, (2) diversification of species composition, (3) shortening rotations, (4) evenage management of affected stands, and (5) removal of severely top-killed regeneration.

4. Forest Insect and Disease Management personnel should conduct aerial surveillance, parasite, egg mass, and impact surveys in 1978 to provide forest resource managers with pertinent information on western spruce budworm activity.

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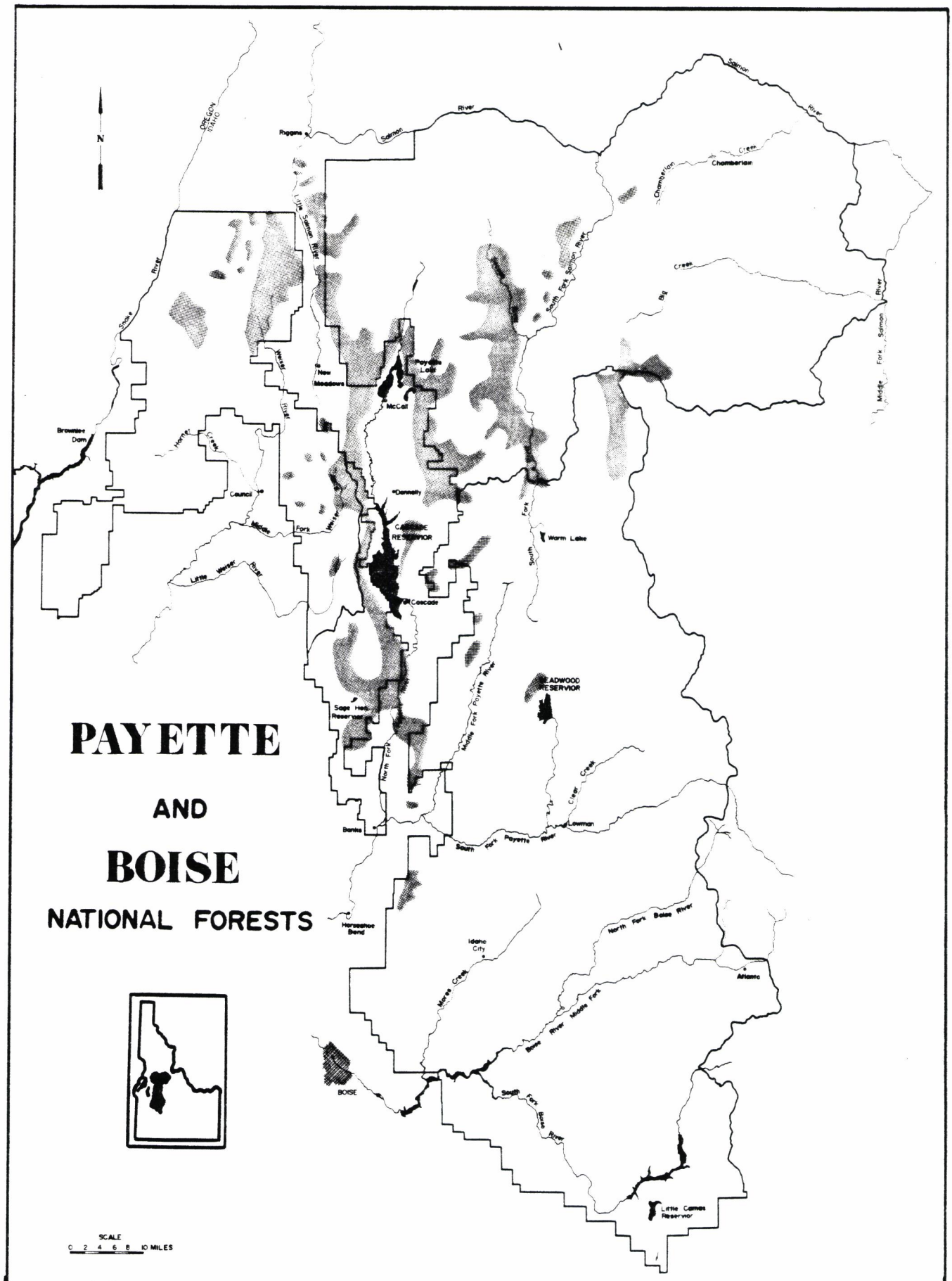


Figure 1. Area of defoliation by western spruce budworm, Boise and Payette National Forests and intermingled federal, state and private lands-1977.

Table 1. Impact of defoliation by western spruce budworm on trees ≥ 5 inches dbh by tree species and damage class ratings, Analysis Units 3, 4 and 5, Boise Payette Infestation-1977.

| Species | Damage Classes | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (0) Not Defoliated | | | | (1) Current Years Defoliation | | | | (2) Current & Older Defoliation | | | | (3) Top-Kill <10% | | | | (4) Top-Kill 11-33% | | | | (5) Top-Kill >33% | | | | (6) Mortality | | | | Totals: | | | |
| | * T/A | % T/A | ** BF/A | % BF/A | T/A | % T/A | BF/A | % BF/A | T/A | % T/A | BF/A | % BF/A | T/A | % T/A | BF/A | % BF/A | T/A | % T/A | BF/A | % BF/A | T/A | % T/A | BF/A | % BF/A | T/A | % T/A | BF/A | % BF/A | T/A | % T/A | BF/A | % BF/A |
| Grand-fir | 4.4 | 3.0 | 1021.4 | 3.8 | 11.8 | 8.1 | 3014.4 | 11.0 | 27.2 | 18.7 | 6578.0 | 24.0 | 19.1 | 13.1 | 2237.1 | 8.2 | 4.9 | 3.3 | 343.2 | 1.2 | 2.0 | 1.3 | 251.3 | 1.9 | .4 | .3 | 41.3 | .1 | 69.7 | 47.9 | 13518.8 | 49.4 |
| Douglas-fir | 4.7 | 3.2 | 1527.2 | 5.6 | 4.8 | 3.3 | 1318.5 | 4.9 | 6.6 | 4.5 | 900.0 | 3.3 | 1.5 | 1.1 | 140.0 | .5 | .01 | 0.0 | 18.0 | .06 | | | | | | | | | 17.6 | 12.1 | 3903.5 | 14.4 |
| Subalpine fir | .1 | .07 | 27.7 | .1 | 1.6 | 1.1 | 118.7 | .5 | 3.4 | 2.3 | 236.0 | .9 | 1.1 | .8 | 15.3 | .05 | 1.8 | 1.2 | 114.4 | 0.4 | | | | | | | | | 8.0 | 5.5 | 512.1 | 1.9 |
| Engelmann spruce | 5.0 | 3.5 | 1127.1 | 4.1 | 4.1 | 2.8 | 1317.2 | 4.9 | 9.2 | 6.3 | 941.4 | 3.4 | 1.4 | 1.0 | 166.6 | .6 | 1.1 | .7 | 113.5 | .4 | .05 | .03 | 27.7 | .1 | .5 | .3 | 81.1 | .3 | 21.4 | 14.7 | 3774.3 | 13.8 |
| Larch | 2.1 | 1.4 | 536.2 | 2.0 | 10.6 | 7.3 | 471.7 | 3.7 | 4.0 | 2.7 | 114.8 | .4 | .05 | .03 | 28.4 | 0.1 | | | | | | | | | | | | | 16.7 | 11.5 | 1151.1 | 4.0 |
| Lodgepole pine | 5.0 | 3.5 | 509.5 | 1.9 | | | | | | | | | | | | | | | | | | | | | | | | | 5.0 | 3.5 | 509.5 | 1.9 |
| Ponderosa pine | 7.0 | 4.8 | 3993.1 | 14.6 | | | | | | | | | | | | | | | | | | | | | | | | | 7.0 | 4.8 | 3993.1 | 14.6 |
| Totals: T/A | 28.4 | 19.6 | | | 32.8 | 22.6 | | | 50.3 | 34.6 | | | 23.2 | 16.0 | | | 7.8 | 5.3 | | | 2.0 | 1.4 | | | .9 | .5 | | | 145.4 | 100 | | |
| % BF/A | | | 8742.3 | 32.0 | | | 6241.0 | 22.8 | | | 8770.1 | 32.0 | | | 2586.6 | 9.2 | | | 589.1 | 2.0 | | | 311.0 | 1.1 | | | 122.4 | .4 | | | 27362.6 | 100 |

* T/A = Trees per acre
** BF/A = Board feet per acre

Table 2. Impact of defoliation by western spruce budworm on trees <5 inches dbh by tree species and damage class rating, Analysis Units 3, 4 and 5, Boise-Payette infestation-1977.

| Damage Classes / Species | (0) Not Defoliated | | (1) Current Year Defoliation | | (2) Current & Older Defoliation | | (3) Top-Kill <11% | | (4) Top-Kill 11-33% | | (5) Top-Kill >33% | | Mortality | | Totals | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | * T/A | % T/A | T/A | % T/A | T/A | % T/A | T/A | % T/A | T/A | % T/A | T/A | % T/A | T/A | % T/A | T/A | % T/A |
| Grand fir | 21.55 | 2.7 | 58.34 | 7.4 | 140.72 | 17.8 | 71.13 | 9.0 | 14.60 | 1.8 | 10.71 | 1.3 | 6.42 | .8 | 323.51 | 41.0 |
| Douglas-fir | 29.50 | 3.7 | 32.00 | 4.0 | 92.13 | 11.6 | 16.42 | 2.0 | | | | | | | 170.00 | 21.5 |
| Subalpine fir | | | 22.85 | 2.9 | 15.00 | 1.9 | 15.71 | 1.9 | 2.14 | .2 | 11.42 | 1.4 | 17.85 | 2.2 | 85.00 | 10.8 |
| Engelmann spruce | 28.38 | 3.6 | 28.10 | 3.5 | 35.71 | 4.5 | 9.28 | 1.1 | 1.42 | .2 | 2.85 | .3 | 5.0 | .6 | 110.77 | 14.0 |
| Larch | .71 | .2 | 2.86 | .3 | 6.43 | .8 | | | | | | | | | 10.00 | 1.3 |
| Lodgepole pine | 37.61 | 4.7 | .71 | .2 | | | .71 | .2 | | | | | | | 39.04 | 5.1 |
| Ponderosa pine | 49.50 | 6.2 | | | | | | | | | | | | | 49.50 | 6.3 |
| Totals T/A | 167.26 | | 144.87 | | 290.00 | | 113.28 | | 18.17 | | 25.00 | | 29.28 | | 788.00 | |
| %T/A | | 21.3 | | 18.4 | | 36.8 | | 14.4 | | 2.3 | | 3.1 | | 3.7 | | 100.00 |

* T/A - Trees per acre

Table 3. Growth loss from defoliation by western spruce budworm to 44 stands, Boise-Payette infestation-1977.

| | Stand # | Name | Grand fir % of Normal | Grand fir Growth Loss CF/A** | Grand fir Growth Loss BF/A*** | All Species % of Normal | All Species Growth Loss CF/A | All Species Growth Loss BF/A |
|---|---|---|---|---|---|---|---|---|
| Analysis Unit 1 (no defoliation) | 101 | Kinney Ck. | 89 | 5.25 | 26.3 | 90 | 5.85 | 29.3 |
| | 107 | Towne Ck. Saddle | NA* | - | - | - | - | - |
| | 308 | Shingle Ck. | 100 | - | - | 100 | - | - |
| | 504 | Telephone Ck. | 100 | - | - | 100 | - | - |
| | | Total | 289 | 5.25 | 26.3 | 290 | 5.85 | 29.3 |
| | | % | 96 | 1.75 | 8.8 | 97 | 1.95 | 10.0 |
| Analysis Unit 2 (light defoliation) | 104 | Horse Ck. | - | - | - | 100 | - | - |
| | 105 | Placer Basin | 94 | 3.01 | 15.1 | 94 | 5.05 | 25.3 |
| | 106 | Butter Gulch | 92 | 8.82 | 44.1 | 95 | 5.81 | 29.1 |
| | 108 | Bullhorn | 94 | 6.30 | 31.5 | 96 | 6.75 | 33.8 |
| | 111 | Twin Fk. Ck. | 88 | 9.96 | 49.8 | 90 | 12.79 | 64.0 |
| | 112 | Little Mud Ck. | 100 | - | - | 100 | - | - |
| | 113 | East Branch | 83 | 14.17 | 70.9 | 88 | 14.17 | 70.9 |
| | 118 | Trail Ck. | 100 | - | - | 100 | - | - |
| | 301 | Bluebunch Sp. | 100 | - | - | 100 | - | - |
| | 302 | Origin Big Ck. | NA | - | - | - | - | - |
| | 303 | Beer Bottle | 100 | .00 | .0 | 99 | .99 | 5.0 |
| | 307 | Bench Ck. | 87 | 7.18 | 35.9 | 93 | 7.18 | 35.9 |
| | 314 | Mica Ck. | 100 | - | - | 100 | - | - |
| | 602 | | - | - | - | 97 | 1.27 | 6.3 |
| | | Total | 1038 | 49.44 | 247.2 | 1252 | 54.01 | 270.3 |
| | | % | 94 | 4.49 | 22.5 | 96 | 4.15 | 20.8 |
| Analysis Unit 3 (moderate defoliation) | 110 | Yellow Jacket | 69 | 12.35 | 61.8 | 86 | 12.34 | 61.7 |
| | 115 | Railroad Saddle | 80 | 8.18 | 40.9 | 90 | 9.97 | 49.9 |
| | 119 | Little Salmon | 85 | 5.07 | 25.4 | 94 | 5.06 | 25.3 |
| | 203 | Sixmile | 88 | 11.80 | 59.0 | 90 | 12.81 | 64.1 |
| | 209 | Red Ridge | 87 | 9.74 | 48.7 | 89 | 9.75 | 48.8 |
| | 402 | BLM | 67 | 17.36 | 86.8 | 79 | 18.49 | 92.5 |
| | 505 | Fourmile | 80 | .75 | 3.8 | 93 | 2.91 | 14.6 |
| | 601 | | 89 | 6.49 | 32.5 | 92 | 8.01 | 40.1 |
| | 603 | | 95 | 3.97 | 19.9 | 97 | 3.98 | 19.9 |
| | 604 | | 100 | - | - | 100 | - | - |
| | 605 | | 96 | 2.12 | 10.6 | 99 | 2.13 | 10.7 |
| | 606 | | 88 | 11.02 | 55.1 | 95 | 11.01 | 55.1 |
| | 607 | | 100 | - | - | 100 | - | - |
| | 609 | | 92 | 18.23 | 91.2 | 92 | 18.23 | 91.2 |
| | | Total | 1216 | 107.08 | 535.70 | 1296 | 114.69 | 573.9 |
| | | % | 87 | 7.65 | 38.3 | 93 | 8.19 | 41.0 |
| Analysis Unit 4 (heavy defoliation) | 201 | N. Brown Ck. | 99 | 1.45 | 7.3 | 98 | 2.38 | 11.9 |
| | 202 | S. Brown Ck. | 97 | 4.80 | 24.0 | 98 | 4.80 | 24.0 |
| | 205 | Sezwell Ck. | 87 | 9.43 | 47.2 | 93 | 11.39 | 57.0 |
| | 206 | Last Chance | 88 | 12.79 | 64.0 | 90 | 12.79 | 63.6 |
| | 207 | Wagon Bay | 77 | 11.68 | 58.4 | 90 | 15.96 | 79.8 |
| | 304 | No Business | 93 | 3.69 | 18.5 | 98 | 3.69 | 18.5 |
| | 401 | Browns Pond | 85 | 4.71 | 23.6 | 94 | 8.28 | 41.4 |
| | 403 | Shady Beach | 97 | .37 | 2.9 | 99 | .02 | .1 |
| | 501 | Split Ck. | 63 | 1.24 | 6.2 | 97 | 1.60 | 8.0 |
| | 608 | | 92 | 8.74 | 43.7 | 94 | 8.74 | 43.7 |
| | | Total | 878 | 59.10 | 295.3 | 951 | 69.65 | 348.0 |
| | | % | 88 | 5.9 | 29.6 | 95 | 6.97 | 34.8 |
| Analysis Unit 5 (severe defoliation) | 506 | Blackmare Ck. | NA | - | - | - | - | - |
| | 507 | Cougar Ck. | 85 | 11.99 | 60.0 | 88 | 12.95 | 64.3 |
| | | Total | 85 | 11.99 | 60.0 | 88 | 12.95 | 64.3 |
| | | % | 85 | 11.99 | 60.0 | 88 | 12.95 | 64.8 |

*NA - No growth rate data
**CF/A - Cubic feet per acre
***BF/A - Board feet per acre